Maine Agricultural Experiment Station

BULLETIN No. 149. DECEMBER, 1907.

POTATO DISEASES IN 1907.

This bulletin contains the results of spraying experiments upon potatoes in 1907 and notes upon potato diseases, new and old. A list of the topics discussed is given on page 288.

Requests for bulletins should be addressed to the
AGRICULTURAL EXPERIMENT STATION,
Orono, Maine.

MAINE

AGRICULTURAL EXPERIMENT STATION

ORONO, MAINE.

THE STATION COUNCIL.

President George E. Fellows	*President*
Director Charles D. Woods	*Secretary*
John A. Roberts, Norway	*Committee of Board of Trustees*
Charles L. Jones, Corinna	
Samuel W. Gould, Skowhegan	
Augustus W. Gilman, Foxcroft	*Commissioner of Agriculture*
Eugene H. Libby, Auburn	*State Grange*
Charles S. Pope, Manchester	*State Pomological Society*
Rutillus Alden, Winthrop	*State Dairymen's Association*
James M. Bartlett	*Members of the Station Staff*
Lucius H. Merrill	
Fremont L. Russell	
Gilbert M. Gowell	
Edith M. Patch	
Warner J. Morse	
Raymond Pearl	

THE STATION STAFF.

Charles D. Woods	*Director*
James M. Bartlett	*Chemists*
Lucius H. Merrill	
Herman H. Hanson	
Arthur C. Whittier	
Joanna C. Colcord	
Fremont L. Russell	*Veterinarian*
Gilbert M. Gowell	*Poultry Investigations*
Walter Anderson	
Edith M. Patch	*Entomologist*
Warner J. Morse	*Vegetable Pathologist*
Raymond Pearl	*Biologists*
Frank M. Surface	
Rex C. Gellerson	*Inspector*
Royden L. Hammond	*Seed Analyst and Photographer*
Annie M. Snow	*Clerk and Stenographer to the Director*
Blanche F. Pooler	*Stenographer*
Henry A. Millett	*Meteorological Observer and Janitor*
Frank D. Sterry	*Laboratory Assistant*

POTATO DISEASES IN 1907.

W. J. Morse.

In comparison with the conditions prevailing for several years, particularly with those of 1906, the season of 1907 presents a decided contrast with regard to the development of the various Maine potato diseases. All through the eastern part of the State, low temperatures prevailed during the entire growing season. Planting and hoeing were delayed from 2 to 3 weeks and spraying largely interfered with. The wet weather at digging time and immediately preceding, greatly increased the amount of loss from rot on unsprayed or improperly sprayed fields.

Early Blight.—*Alternaria solani,* which was very prevalent and destructive during the dryer season of 1906, was seen only on a few fields, late in the season—little or no damage resulting from this cause.

Late Blight.—*Phytophthora infestans.* For several seasons preceding 1907 this fungus has been responsible for very little damage in Aroostook County. This has been due partly to the almost universal practice of spraying and partly to the prevailing weather conditions. A careful search over several hundred acres the last of August, 1906, failed to show a single leaf of well defined late blight. In 1907 it was first seen by the writer August 8 at Ft. Fairfield, where the disease was well distributed and had already destroyed the entire foliage on one field. Very soon all but the most thoroughly sprayed fields were severely attacked. Several days of bright, dry weather beginning the third week in August decidedly checked the epidemic in most localities. Wet weather about September 1 started the blight again with renewed vigor, this time lasting until frost came. Continued wet weather through September resulted in a large amount of rot following blight except on the most thoroughly sprayed fields.

A somewhat peculiar form of the dry rot caused by this fungus on potatoes from the stored crop of 1906 is elsewhere described.

The complaints from scab were much less numerous than in 1906, and so far as could be ascertained from observation and correspondence the percentage of loss from this cause was actually much less. This is in direct contradiction of the statement frequently made that scab is more prevalent in wet seasons than in dry.

Internal Brown Spot of the Tuber. This is a non-parasitic disease, common in some parts of Europe although but little known in America. Specimens of this disease have, as yet, been received from only one locality in Maine.

Black Leg is another disease or possibly a type of disease which is recorded for the first time from Maine. Since 1903 somewhat similar diseased conditions of potatoes have been reported from Ohio, Colorado, Florida, Vermont and Canada, under various names such as "potato rosette," "collar rot," "little potato disease," "black leg," etc. The reader is referred to the more detailed description for the characters, appearance and distribution of this disease.

A discussion of the following topics with reference to potato diseases and their treatment, based largely upon the studies of the past season, will be found in the succeeding pages.

Dust Sprays vs. Wet Bordeaux for Potato Blight.

The use of dry or dust sprays is by no means a new idea, but their extended use for potato blights is a matter of quite recent development in Maine. A few dust machines, used in 1906, almost without exception as far as the writer can ascertain, upon fields where no unsprayed or wet bordeaux checks were saved, and in a season very free from late blight, led many to believe that dusting is an ample protection against potato blights. As a result certain limited sections used dry sprays almost entirely during 1907.

If equal protection can be secured, dusting has many advantages over wet bordeaux, even though the first cost of the necessary materials for the former are much more than for the latter. The advantages lie chiefly in the ease, rapidity and cheapness of application. Very frequently it may be necessary to cart the water for wet bordeaux half a mile or more. This hauling of 1000 or 2000 gallons of water every time a 20-acre field is sprayed is no small item of expense. Furthermore the hauling of a 100-gallon spray tank requires two horses and the services of a second man are necessary for a large part of his time to prepare the spray while the other man is applying it. The dust machines are light, even when loaded to their full capacity. One man with a light, fast-walking horse, can cover as much ground with a dust machine in 1 day as can be done in 2 or 3 days with a pair of workhorses attached to a heavy sprayer. On account of the present scarcity and high price of labor these points in favor of dusting have appealed quite strongly to potato growers.

For several years the Station has been carrying on experiments to test the relative merits of dust and wet sprays. Only part of this data has been published.*

In all trials previous to 1907 the weather conditions were such that little or no late blight occurred and as a consequence no well marked results were secured. The trials of the past season were conducted upon the farm of and in cooperation with the Commissioner of Agriculture, Hon. A. W. Gilman, of Foxcroft. All of the ingredients of each kind of spray were

* Woods, C. D. and Bartlett, J. M., Me. Agr. Exp. Sta. Bul. 112, p. 6 (1905) and Bul. 126, p. 34 (1906).

carefully measured and weighed at each application and the yield of the resulting crop determined by weight.

The experimental field was well drained, sloping slightly to the east, the rows running north and south. The soil was well adapted to potato growing and uniform throughout. The land had been in sod for several years. In September, 1906, a light coat of stable manure was applied with a manure spreader. The field was plowed in May and thoroughly harrowed before planting, which was begun on June 8. On account of a storm, that portion including Plots 8 to 13 was delayed in planting a few days, but the work was all completed within a week from the beginning. One thousand pounds per acre of a commercial fertilizer carrying 3 per cent nitrogen, 6 per cent phosphoric acid, and 10 per cent potash was applied at the time of planting. The plants were very strong and vigorous, and after the first few weeks of growth absolutely no difference could be detected in the appearance of the different plots till the foliage began to show the effects of blight.

For experimental spraying 13 plots about 39 rods long and containing approximately one-third acre each were laid off on this field beginning on the east side. These plots were all sprayed 6 times, on the following dates, July 17 and 27, August 2, 9, 16 and 27.

Plots 1, 3, 5, 9, 11 and 13 were sprayed with standard wet bordeaux. For the first 3 applications single nozzles were used to each row, applying not over 45 gallons per acre. The last 3 times 2 nozzles per row were used, applying 70-75 gallons per acre.

Plot 2 was dusted with 6 pounds of sal bordeaux per acre, and Plot 4 with 10 pounds of sal bordeaux per acre.

Plot 6 was an unsprayed check. It was sprayed with paris green only for Colorado beetles.

Plot 7 was sprayed with sodium benzoate bordeaux,* applied at same rate and the same amount as standard wet bordeaux.

---

* This spray was tried at the request of a firm which manufactures sodium benzoate and according to the formula which they furnished as follows: Copper sulphate 1 pound, lime 1 pound, sodium benzoate ½ pound, water 50 gallons. "Dissolve the different ingredients separately in about the whole quantity of water required, then combine and add sufficient water to make up to 50 gallons." The manufacturers state

Plot 8 was dusted with 6 pounds Leggett's Blight Dust No. 2 per acre.

Plot 10 was dusted with 6 pounds Bowker's Dry Boxal per acre.

Plot 12 was sprayed with 10 pounds Bowker's Boxal Paste per acre.

To apply the dust sprays a horse power cart of the type known as the "Beetle" was used. To secure uniform applications and to avoid changing the regulator on the machine for each plot, more or less prepared or ground lime was thoroughly mixed with the dust used on each plot and applied with it, i. e., the dust application was made up to equal volume on each plot with lime. The lime simply acted as a dilutant and in no way interfered with the action of the dust spray. The Boxal paste was mixed thoroughly in the keg at each application and then the required quantity weighed out. With a small quantity of water this was stirred in a pail till all lumps had disappeared and then thoroughly mixed and agitated with the necessary amount of water in the spray tank.

The Boxal preparations claim to serve as insecticides as well as fungicides, therefore no paris green was used with these and none was necessary. On the other plots from one to one and one-half pounds per acre of paris green was used at each application as long as necessary, mixing it with the dust or wet bordeaux as the case might be.

The field was visited nearly every week during the season, and at no time did over 10 days pass without observations as to the condition of the foliage. Early blight *(Alternaria solani)* was practically absent except for a small amount late in the season, and practically all of the damage to the foliage resulted from attacks of the late blight *(Phytophthora infestans)*. The record for the condition of the foliage after blight was first observed is as follows:

further: * * * "The sulphate and benzoate exchange places forming 2 other materials viz. sodium sulphate and copper benzoate. Now it is the copper benzoate that combines all the virtue of the spray, it being infinitely less soluble than the original chemicals while combining the germicidal and fungicidal value. Copper benzoate is very slow to wash off with the rain and practically the only successive sprayings necessary are those required to protect new growth."

August 9. Considerable blight on Plot 6, just beyond the center of the rows. Some less on Plots 7 and 8 in about the same locality. Remainder of the plots healthy. This had all developed since the last observation on August 2.

August 16. Plots sprayed with wet bordeaux free from blight, except a little on Plot 5, adjoining the bad outbreak on the unsprayed check, Plot 6. Plot 2 showed some late blight near the south end, Plot 4 an occasional blighted leaf, Plot 6 blight generally distributed over entire plot except on north end. Several rods in center badly damaged. Plots 7 and 8 diseased almost as much as 6. Plot 10 some blight on south end. Plot 12, a few blighted leaves.

August 27. Following the last record several days of bright clear weather held the progress of the disease largely in check. The wet bordeaux plots were clean except as noted on August 16 and here there was no increase. All other plots showed some increase of blighted leaves. Following this came another period of rainy weather so that two weeks later the disease had developed to such an extent that the plots could be distinguished as alternate green and brown strips as far as the field could be seen.

September 11. Plot 1, free from late blight, a little early blight. Plot 2, 50 per cent of leaves dead. Plot 3, free from blight except for an occasional leaf. Plot 4, a little healthier than Plot 2. Plot 5, the slight outbreak noted in one portion of this plot appears to have been entirely checked at the fifth spraying on August 16. Plot 6, foliage all dead. Plot 7, 50 per cent of leaves killed. Plot 8, 75 per cent of foliage killed. Plot 9 shows an occasional blighted leaf. Plot 10, 75 per cent of leaves killed. Plot 11, about like Plot 9. Plot 12, 10 to 15 per cent of leaves killed by blight. Plot 13, very little blight, better than Plots 9 and 11.

September 25. Wet sprayed plots showed 80 per cent to 90 per cent of foliage still green on this date. On all others the plants were practically dead except on Plots 7 and 12, where the stalks were alive but the foliage dead.

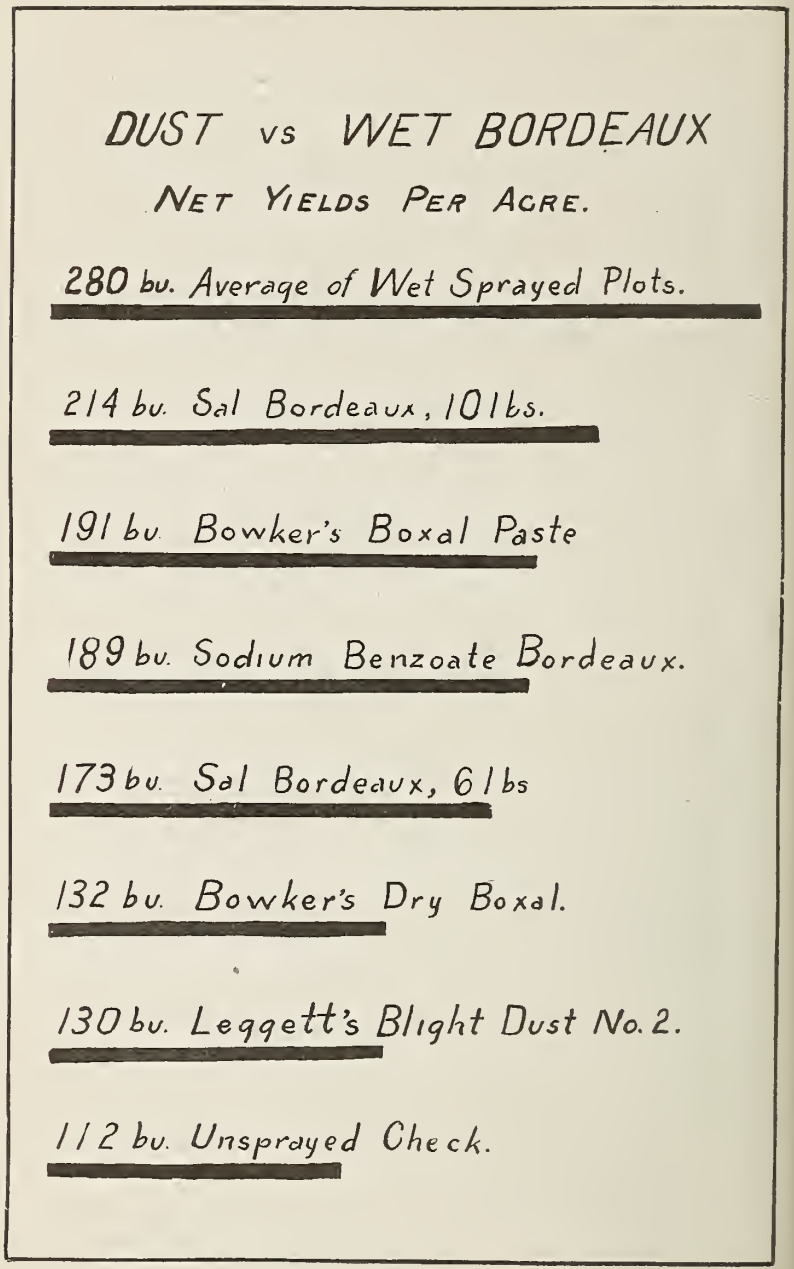
October 5. Plants on Plots 7 and 12 entirely dead, while those sprayed with standard bordeaux were fully as healthy as at last record. The living plants were all killed by frost during the following week.

The crop was harvested during the week beginning October 14. A summary of the yields and losses resulting from the use of dust sprays, etc., as compared with the use of standard wet bordeaux, are given in the following table. However, it should be mentioned that this table, a record taken at digging time, by no means represents the entire loss on the dusted plots. The crop from these plots contained more undersized, immature tubers and was in general of an inferior quality. Moreover, Mr. Gilman informed the writer a month after the potatoes had been placed in storage that those from the dust plots were showing more or less decay while there was practically none in those harvested from the plots sprayed with wet bordeaux. The relative net yields are shown graphically on page 294.

Table showing total and net yields of potatoes per acre from the use of different fungicides.

Plot number.	Treatment.	Net yield per acre (bushels).	Rot per acre (bushels).	Total yield per acre (bushels).	Per cent of decay.	Net loss in bushels per acre.*	Net loss per acre at 50 cents a bushel.
1	Wet Bordeaux	288	18	306	5.9		
2	Sal Bordeaux, 6 lbs	173	68	241	28.2	107	$53 50
3	Wet Bordeaux	312	18	330	5.5		
4	Sal Bordeaux, 10 lbs	214	57	271	21.0	66	33 00
5	Wet Bordeaux	293	28	321	8.7		
6	Check unsprayed	112	95	207	45.9	168	84 00
7	Sodium Benzoate Bordeaux	189	59	248	23.8	91	45 50
8	Leggett's Blight Dust No. 2	130	62	192	32.3	150	75 00
9	Wet Bordeaux	257	18	275	6.5		
10	Bowkers Dry Boxal	132	74	206	36.0	148	74 00
11	Wet Bordeaux	245	13	258	5.0		
12	Bowkers Boxal Paste	191	48	239	20.1	89	44 50
13	Wet Bordeaux	284	25	309	8.1		

* As compared with average net yield (280 bushels) of wet sprayed plots 1, 3, 5, 9, 11 and 13.


DUST vs WET BORDEAUX
NET YIELDS PER ACRE.
280 bu. Average of Wet Sprayed Plots.
214 bu. Sal Bordeaux, 10 lbs.
191 bu. Bowker's Boxal Paste
189 bu. Sodium Benzoate Bordeaux.
173 bu. Sal Bordeaux, 6 lbs
132 bu. Bowker's Dry Boxal.
130 bu. Leggett's Blight Dust No. 2.
112 bu. Unsprayed Check.

DISCUSSION OF RESULTS.

So far as the results of the foregoing experiments show, none of the substitutes for wet bordeaux in any way approached it in efficiency as a preventive for late blight. While none of the dust sprays in any way produced the results claimed for them by the manufacturers and others, they all showed more or less fungicidal value. This was least with Leggett's Blight Dust No. 2 and Bowker's Dry Boxal, which only showed a gain of 18 or 20 bushels per acre resulting from 6 applications of 6 pounds each, when compared with the unsprayed check. The same amount of Dust Sprayer Manufacturing Co's. Sal Bordeaux increased the yield 60 bushels per acre, while 10 pounds of the same material to an application gave an increase of 102 bushels per acre. The fact should not be overlooked that wet bordeaux under the same conditions gave an increase of 168 bushels per acre. The value of the wet bordeaux as compared with the dust sprays is more apparent from the last column of the table. Estimating the value of potatoes at 50 cents per bushel, which was about the price being paid when the crop was dug, it will be seen that the loss from dusting as compared with the average yield of the wet sprayed plots varied from $33.00 per acre from using 10 pounds to an application of Sal Bordeaux to $75.00 per acre where 6 pounds of Leggett's Blight Dust No. 2 was used per application. Sodium Benzoate Bordeaux and Bowker's Boxal Paste, the former containing only one pound of copper sulphate and one-half pound of sodium benzoate to 50 gallons of spray, gave better results than each of the dust sprays except the 10-pound application of Sal Bordeaux. However, there does not appear to be any particular merit in them as substitutes for standard bordeaux. Boxal paste costs in 100-pound lots about 3 times as much as the materials to prepare an equal amount of home-made bordeaux, and the writer found it nearly as much work to get the paste in proper condition for spraying as it was to make the same quantity of bordeaux. Unfortunately no check plot treated with a bordeaux mixture containing one pound of copper sulphate to 50 gallons of water was provided, so it is impossible to say whether the partial protection on Plot 7 was due entirely to the small amount of copper sulphate which it contained or in

part to the addition of the sodium benzoate. It seems reasonable to assume that the latter was of some value, for as is shown elsewhere sodium benzoate apparently reduced the amount of scab where seed tubers were treated with a solution of it, and its value as a preservative in preventing the growth of the ordinary saprophytic fungi is well known.

The foregoing account and discussion is based wholly on the Station experiments at Foxcroft, where every endeavor was made to give the dust sprays a fair and impartial trial. Before leaving the subject it should be mentioned that a large number of dust machines were used the past season around Maple Grove and Ft. Fairfield. While there was considerable difference of opinion, a number of growers there expressed themselves as well satisfied with the results obtained from dusting. The writer on August 22 spent nearly the entire day driving from one field to another in this locality and was convinced that at this time the dust was of considerable value in keeping the blight in check. However, there was very little opportunity for accurate comparisons. With one or two possible exceptions there were no fields or parts of fields lying side by side where both had otherwise been treated alike and one sprayed with dust and the other with wet bordeaux the same number of times on approximately the same dates. No unsprayed checks were left in any case. Many cases were found also both with the dusting and wet spraying where it seemed evident that the applications were not begun till after the blight had become well established on the plants.

Attempts were made in the spring to arrange for cooperative dusting experiments in this locality but without much success. Most of the owners of the dust machines were so thoroughly convinced of the value of the method from the experience of the previous year that they did not wish to bother with the wet bordeaux sufficiently to spray a part of their fields in this way and keep the necessary records. One gentleman did attempt this but unfortunately waited too long before beginning spraying, and neglected to keep a record of the dates when he did spray. On August 22 both parts of this field showed more or less blight, but one was about as bad as the other. A later visit, September 19, the day following a severe frost, indicated that the wet sprayed tops remained green somewhat longer than

those which were dusted. As near as could be judged 30 per cent to 50 per cent of the foliage on the wet sprayed portion was alive and practically none on the dusted portion when the freeze came.

Relative Efficiency of Light and Heavy Spraying: Frequency of Spraying.

While the losses from early blight are not so marked as from late blight, and often pass unnoticed, careful observations show that, especially in dry years, this fungus does much damage even on what are generally considered well-sprayed fields. The examination of a large number of fields in Aroostook County in the late summer of 1906 indicated that early blight was not controlled to any great extent by the methods of spraying commonly practiced there. Since in the experience of the writer a moderate number of thorough, heavy sprayings gave ample protection against this fungus,* it seemed best to test the matter on a large scale in two different parts of the State. The places selected were Houlton, Aroostook County, near the eastern border, and Foxcroft, Piscataquis County, near the center of the State. The former on the John Watson farm and the latter on Commissioner Gilman's farm, being a continuation on the south of the field described under the dusting experiment.

On account of the nature of the season very little early blight developed, but the results secured furnish some interesting data with reference to how often and how thoroughly we should spray for late blight.

Plots were selected on each field as nearly as possible to an acre in size. Plot 1 to be double sprayed 6 times (twice on the same date going in opposite directions on the row). Plot 2 to be double sprayed 3 times and Plot 3 to be single sprayed 6 times. In practice this going over the ground twice for the double spraying would be avoided by doubling the number of nozzles to the row, so arranged that half pointed slightly to the front and half to the rear, taking care that the cones of the spray are so adjusted and directed as to cover the entire width of the foliage on the row. Thus the labor for the 6 double applications would be no more than for 6 single. If the extra

* Vt. Sta. Rep. 18, p. 275 (1905).

time required to prepare the mixture is disregarded, the 3 double sprayings would only take half the time of the 6 single applications.

At Foxcroft Plots 1 and 3 were sprayed July 18 and 27, August 2, 9, 16 and 27. Plot 2 on July 18, August 2 and 16. At Houlton Plots 1 and 3 were sprayed July 15 and 22, August 3, 10, 15 and 22. Plot 2 on July 15, August 3 and 15.* At Foxcroft single nozzles applying about 45 gallons to a single and 90 gallons to a double application were used for the first 3 sprayings, while for the last 3 sprayings double nozzles were used, giving 70-75 gallons for single and 140-150 gallons for double applications. At Houlton double nozzles applying about 80 gallons for a single application and 160 gallons for a double application were used for all 6 sprayings.

On account of the construction of the sprayers it was impossible to adjust the nozzles to a sufficient height so that the entire outer margins of the rows were protected after the tops fully covered the ground. This difficulty was partly overcome at Foxcroft and it doubtless explains, in part, the lower percentage of rot obtained there. At Foxcroft no blight was seen until August 27 when a little early blight was seen on Plot 2, the others being entirely healthy. All of the plots were quite well protected through the season. From September 11 until shortly after October 5 when the plants were killed by frost, Plot 2 showed a small amount of late blight and some early blight, though not enough of the latter to do any damage. Occasional leaves affected with late blight could also be found on Plot 3, but none on Plot 1. On Plot 1 the early blight was almost entirely confined to marginal leaves where they were imperfectly protected by the spray. There was about the same

* On account of severe rains and the exceeding prevalence and destructiveness of the late blight during the first week in August it was thought best to make an extra single application to Plot 2 which was originally planned to be double sprayed as near July 15, August 1 and 15 as possible. Accordingly Plot 2 at Foxcroft was gone over with a single application on August 9. On account of not understanding the directions the man in charge at Houlton made this application on August 8 not to Plot 2, but to Plot 3 which was to receive 6 single applications and came in for its regular spraying on August 10. This probably explains why as later noted there is considerable disagreemant with regard to the relative results from these plots in the two localities.

amount of early blight on Plot 3 as on Plot 2, but in both cases it was much more destructive on the outer, unprotected leaves. In fact on all the plots at Foxcroft after the middle of September a distinct black line could be observed midway between the rows. This was made by the browning of the unprotected leaves as a result of the combined injuries of early blight, flea beetles and grasshoppers. The repellent qualities of bordeaux upon the insects mentioned was very marked.

At Houlton late blight could be found after August 20 on all the plots where the leaves were imperfectly protected at the margins, Plot 1 looking a little the healthiest, with not much choice between the other two. These plants were killed by frost on September 8. There was practically no early blight on the Houlton field. The crop at both places was harvested during the week beginning October 14. The yields and amount of rot are given below in tabular form.

YIELDS OF POTATOES FROM SINGLE AND DOUBLE SPRAYING IN BUSHELS PER ACRE.

	Total yield per acre.	Net yield per acre.	Rot per acre.	Per cent of rot.
Foxcroft.				
Plot 1, Double Sprayed 6 times,	345	343	2	0.6
Plot 2, Double Sprayed 3 times,*	303	298	5	1.7
Plot 3, Single Sprayed 6 times,	300	280	20	6.6
Houlton.				
Plot 1, Double Sprayed 6 times,	462	420	42	9.1
Plot 2, Double Sprayed 3 times,	362	277	85	23.5
Plot 3, Single Sprayed 6 times,*	392	343	49	12.5

* See note on p. 298.

DISCUSSION OF RESULTS.

The profits from 6 heavy applications in a season like that of 1907 are very apparent. These plots gave an increase of 45 bushels per acre at Foxcroft and 77 bushels per acre at Houlton over the yields of the better of the other 2 plots, while at the prevailing prices of copper sulphate and lime the cost of the extra materials used would not be over $3.00 per acre.

The results from the 6 single *vs.* the 3 double applications are somewhat contradictory. At Houlton the former gave 66 more bushels per acre while at Foxcroft the latter was the better by 18 bushels per acre. This may be partly accounted for because, as has already been stated, the modified Houlton experiment was really 7 single sprayings compared with 3 double, while at Foxcroft there were 6 single sprayings compared with 3 double sprayings with a single one added to make up for excessive washing by rain. That a moderate number of thorough sprayings applied at the right time are quite effective against late blight is well shown by the Foxcroft experiment in comparing the results obtained from Plots 2 and 3. However, it should not be overlooked that additional thorough applications produced still better results, as is seen in the largely increased yields from Plot 1 at both places.

The per cent of rot in both fields is instructive in that it corresponds quite closely with the ability of the machines used to cover the entire foliage of a row. When compared with the loss of 45.6 per cent from rot on the unsprayed check of the adjoining dust experiment the amount of loss from rot in the part of the experiment at Foxcroft is quite satisfactory. The loss from rot of from 9.5 per cent to 23.5 per cent at Houlton is entirely too high and might have been materially lessened if the adjustments on the machine had admitted the raising of the nozzles to sufficient height to cover the entire row with the spray cone. However, it should be said that the work of spraying this field was as carefully and thoroughly done as could be under the circumstances. This is very evident when we consider that on Plot 1, a measured acre, produced 420 bushels of sound potatoes and only about 5 bushels of these were sorted out as below merchantable size. Moreover, out of a large number of fields examined only one other was seen in Aroostook County which was so well sprayed as this one.

Can Our Spraying Methods Be Improved?

After going over hundreds of acres of potatoes this past summer and talking with the growers as to the methods used in spraying, the writer would answer this question with a decided affirmative. A most encouraging fact is that many of the growers themselves agree with this conclusion and state their determination to return to the more thorough practice formerly in vogue. It is probably not excessive to state that in most districts at least 30 per cent of the crop in 1907 was lost from rot, to say nothing of the reduction in yield from the early killing of the tops. In many cases 50 per cent or 60 per cent and even 75 per cent of the crop went to the starch factory. The station experiments and the results obtained by growers who followed similar methods indicate that a large proportion of this loss could have been prevented by proper spraying.

Spraying must always be looked upon as a form of insurance, and for potato blights is a preventive and not a cure, hence it must be begun before the blight appears. Various causes are responsible for the losses during 1907. The almost entire absence of late blight for a few seasons led some to question the value of spraying and many of these individuals announced their intention of not spraying at all this season. These, and many others from one cause and another, waited till their plants were well infested and then began to spray—a proceeding about as effective as turning a hose on the outside walls of a house to stop a fire in the interior partitions. Here, frequently, enough bordeaux was used during the season but not at the proper time. Others were provided with sprayers having single nozzles so placed as to be only a few inches above the full grown tops. They drove over the fields with these carts leaving a deep blue line about 6 inches wide on the center of the foliage of each row and went their way apparently satisfied, for *had they not applied 50 gallons per acre?* Here again, it is possible that enough bordeaux was used, but it was not properly distributed to protect the entire foliage. In cases where the entire foliage was not covered with bordeaux the unprotected leaves blighted and the spores from their surfaces were washed down into the soil and thus infected the tubers with rot.

In making bordeaux mixture, too frequently guess work is substituted for weights and measures. There is also a tendency to vary the proportions of the ingredients to a marked degree. As low as 3 pounds of copper sulphate to 100 gallons of spray and as high as 24 pounds to the 100 gallons were found to be used, although these were exceptional cases.

In view of these facts it seems well to supplement the directions for spraying which have been sent out by the Station during the last dozen years, giving special emphasis to the lessons which the experience of the last season has furnished.

All power machines so far as observed met the requirements with regard to the construction of pumps and nozzles, namely, providing a constant high pressure and a fine, mist-like spray. Nevertheless every type of sprayer so far seen in Maine potato fields is inefficient as it comes from the manufacturers. Most of them are only provided with a single nozzle to a row and, when the foliage is full grown, can be raised but a few inches above the top of the row. This arrangement is sufficient for the first and possibly the second spraying but should never be used thereafter. Every spraying should mean the deposition of a thin film of bordeaux on the surface of each leaf. Two nozzles per row are necessary to accomplish this and 3 would be better. These should be so arranged that they will evenly cover the entire foliage of a full grown row. Where double nozzles are used they should be farther apart than is commonly the case, and if possible admit of some adjustment as to direction. It should be possible to raise the line of nozzles, as the plants grow, to such an extent that each time the bordeaux is applied the outer margins of the spray cones extend just beyond the margins of the foliage of the row, thus giving uniform protection to all leaves. It is with respect to the extent of this adjustment that most machines are deficient. If a machine does not meet these requirements it should be remodeled till it does. *Each leaf should be covered at each spraying regardless of whether it takes 50, 100 or 150 gallons of bordeaux per acre.*

For late blight, spraying should ordinarily be begun from 10th to the 20th of July. If the weather is dry and sunny one can wait until the latter date or even later, but if very moist, cloudy weather prevails the former date is none too early. In average seasons 4 and sometimes 3 thorough sprayings will be

sufficient. In a season like the past, 5 or even 6 are necessary. More frequent and thorough spraying is necessary for early blight, and it must as a rule be begun quite early in the season.

Therefore, unless one has made a careful study of the different blights, and the relation of their development to weather conditions, the following rule is probably the only safe one to follow: *Begin when the tops are 6 or 8 inches high and spray every 10 days (every week if the weather is very cloudy and rainy) until the last of August or the first of September.* In any event spraying must be begun some days before the average observer will detect blight on the leaves. Do not stop for rainy weather, this is just the time when spraying is most needed. Each application should be made as often as it is necessary regardless of the weather. If the mixture is properly prepared and it once dries on the leaves, which usually takes place in an hour's time, it will withstand much more washing than is commonly supposed.*

In the sense of the term used, properly prepared bordeaux consists of 50 gallons of water, 5 pounds of copper sulphate, and 5 pounds of fresh stone lime (some are using ground or hydrated lime with apparent success). The copper sulphate should be dissolved and the lime slaked in different vessels. Each solution should then be diluted with half of the water and then the *cold, dilute sulphate and milk of lime solutions quickly united and thoroughly mixed.* Never pour the concentrated solutions together as an inferior mixture is sure to result. If it is desired to increase the amount of copper sulphate used per acre, do not make a stronger mixture but increase the number of nozzles per row or go twice over the piece in opposite directions on the rows, provided in the latter case that the nozzles are so arranged as to cover the entire width of the row at each application.

Most large growers use stock solutions of lime and copper sulphate. The most convenient plan for this is to slake 100

* The writer has specimens of leaves taken at Foxcroft, October 5, 1907, which are well coated with bordeaux mixture, yet they were collected 38 days after the last spray was applied. At Orono during this period rain fell on 21 different days making a total of 6.66 inches. 2.18 inches of this fell in 24 hours. The two places are not over 40 miles apart by air line and it is believed that the rainfall did not vary materially.

pounds of lime in a 50-gallon cask and then fill up with water. (This milk of lime solution should be strained before using.) Fill another cask of equal capacity with water and suspend in this near the top a sack containing 100 pounds of copper sulphate, which will usually dissolve in 24 hours. If thoroughly stirred just before using, each gallon of this stock solution will contain 2 pounds of copper sulphate or lime as the case may be. The most convenient method of preparation is to have an elevated platform above the top of the spray cart. Where running water is not available this platform can be built over a small stream or well and a pump connected to the water supply, so placed that it will deliver over the top of a barrel placed on the platform. Two other casks in addition to those for the stock solutions are now necessary, each with a piece of hose 3 or 4 feet long connected to the bottom. When not in use the outer end of the hose is elevated above and fastened to the top of the cask. When ready to prepare a tank full of mixture, the stock solutions are well stirred and 2½ gallons of concentrated copper sulphate solution is *measured* into one cask and 2½ gallons of lime solution into the other and each filled half full for a 50-gallon tank. For a 100-gallon tank 5 gallons each of the stock solutions are used and the casks filled full of water. These casks for the dilute solutions should be at the edge of the platform. Now back the spray cart underneath and quickly lower the hose attached to each barrel and insert it in the opening of the tank on the spray cart. The cart is thus quickly loaded and the dilute, cold solutions quickly and thoroughly mixed.

By following these directions in preparing and applying bordeaux mixture the losses from late blight and the rot associated with it can be entirely prevented in any ordinary season, while in a season like the one just passed the loss can be reduced to a minimum if the work is thoroughly and carefully done.

Treating Seed Potatoes with Formaldehyde Gas to Prevent Scab.

In Bulletin No. 141 of this Station attention was called to a rapid increase of potato scab in Maine during recent years. In discussing preventive measures especial stress was laid upon the importance of using seed tubers as free from scab spots as

possible, and as a farther precaution it was stated that the seed should be treated with a disinfectant to destroy any germs of the scab fungus which might be present. For small lots soaking in formalin or corrosive sublimate solutions is the usual method, but for the large grower or seed dealer formaldehyde gas, generated by the use of potassium permanganate, was recommended. This is a much more convenient and rapid method of treating the seed, but up to the present season it had not been tried on a commercial scale.

Through the courtesy of Mr. John Watson of Houlton a 20-acre field in that town was placed at the disposal of the Station to test the matter on a large scale. About one-half of this land had never been planted to potatoes before, while the remainder had been in cultivation for many years. A house formerly stood on this part of the field and presumably some of the land near the house was devoted to garden purposes. One portion of the old land also had been used in an alfalfa experiment in 1904. Of the part planted to alfalfa one-third was limed, one-third treated with a heavy application of wood ashes, while commercial fertilizer alone was used on the remainder. Hence, it was not expected that scab could be cut down materially on the old ground, but it was hoped that its introduction into the new soil could largely be prevented.

For a disinfecting chamber a room was partitioned off in the basement of the barn. This chamber was 15 feet 3 inches by 11 feet 8 inches and 7 feet 7 inches high and was large enough to treat 75 barrels of seed at one time. There was already a plank floor and the side of the barn formed the back wall of the chamber. The floor was first covered with builders' paper and then with rough boards. To build the walls the studding was set and first covered with paper and then unplaned boards nailed over this on the inside. The top was first boarded over and then this and the back wall were covered with paper held down by strips of lath nailed over the joints. Care was taken to cover with paper all joints at the corners and at the junction of the side walls and floor. The door was carefully fitted and shut into a joint covered with paper. When the door was closed 3 wooden cleats or bars were placed across it passing under other slightly slanting cleats nailed to the studding, thus drawing the door tight against the casing.

Thirty slat-work crates or drawers each containing about 2½ barrels were made to hold the potatoes while being treated. These were 4 feet 4 inches by 3 feet 7 inches, and 9 inches deep. The sides were made of solid inch board while the ends and bottom was constructed of slats of the same material 1½ inches wide and placed an inch apart. The interior angles were reinforced by a triangular strip made by splitting a piece of 2x2 from corner to corner. These crates were arranged in vertical tiers of 5 each on opposite sides of the room. To support them while in use 2x4 scantlings were placed upright between the tiers, one near each corner, and securely fastened to the floor and ceiling. Pieces of 2x2 were then spiked crosswise on these uprights in such a way as to support the crates one above the other and to allow their being pulled out when empty like drawers in a cabinet. When in place there was a space of 4 inches between the top of the one crate and the bottom of the next above, and a 10-inch open space in the rear of all, thus providing for free circulation of the gas on all sides. In the center of the room between the 2 rows of tiers was an aisle somewhat wider than the length of the boxes. This was provided to facilitate the filling of the crates and to leave an open central space in which to generate the gas. As will be shown later there should be no potatoes directly above the generator, in order that the gas may mix with the air somewhat before it comes in contact with the surface of the tubers. If this is not done there is danger of injuring the germinating qualities of those tubers directly above the generator and in contact with the strong, hot gas as it is given off. Figure 45 shows the appearance of these crates when in position.

For a generator a small galvanized washtub about 15 inches in diameter at the bottom was placed in the center of the room about a foot from the floor, midway between the 2 lines of crates filled with potatoes. When ready to use 31½ ounces of potassium permanganate was spread evenly over the bottom of the tub, then 4 pints and 1 ounce of 40 per cent formaldehyde poured over this.

* Approximately 23 ounces of potassium permanganate and 3 pints of formalin to the 1000 cubic feet. See Bulletin No. 141, p. 89.

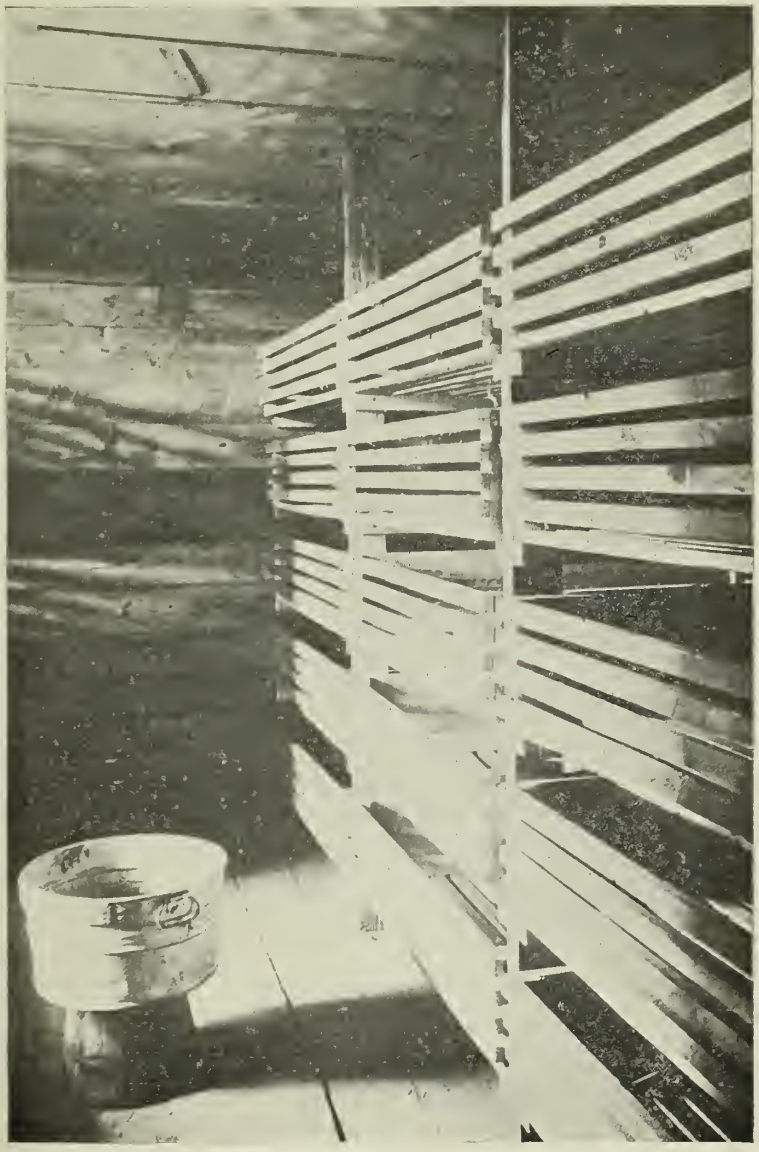


Fig. 45. Interior of disinfecting chamber, showing slat-work bins and position of tub used for a gas generator.

The tub was given one rapid tilt to entirely wet the potassium permanganate with the formalin and then the door was quickly and tightly closed from without. The almost entire absence of the odor of escaping gas while the treatment was in progress indicated that the room was practically air tight. The door remained closed for 24 hours and when opened the gas was still so strong that it was impossible to work in the room for from 20 to 30 minutes. In fact 3 weeks after the disinfection was finished a distinct odor of formaldehyde could be detected in the room.

The seed for the entire 20 acres was treated in this way, care being taken to place the treated seed in barrels which had never been used for potatoes before. This to avoid contamination in taking to the field after treatment.

To secure more accurate data than could be obtained from the general results from the large field, 2 barrels of potatoes were obtained which were said to be sorted from the same lot. The tubers of one barrel, which are referred to as "scabby" seed, were so scabby that they were absolutely unfit for market. Figure 46 is a fair example of these. Those of the other barrel, represented by Figure 47, are referred to as "smooth" seed in the following account. They were quite free from scab, although frequently, as in the illustration, 1 or 2 scab spots could be found on a tuber. Each barrel of seed was divided into 4 different lots according to treatment; care being taken not to mix the smooth and scabby seed of each treatment.

The treatment of the different lots was as follows: No. 1. Soaked 2 hours in a solution containing one-half pint of formalin in 15 gallons of water. No. 2. Treated with formaldehyde gas as described above. No. 3. Soaked 2 hours in a solution containing 20 ounces of sodium benzoate in 15 gallons of water. No. 4. Untreated. Since soaking in formalin solution is one of the 2 standard remedies for scab, Nos. 1 and 4 were inserted as checks for comparison. The writer is not aware that sodium benzoate used in No. 3 has been tried for this purpose before, but the well-known qualities of this chemical as an antiseptic suggested its possible value as a method of treatment for potato scab.

The crop was planted May 23, each treatment and each kind of seed in each treatment being kept separate. The treated

seed was perhaps slightly slower to germinate, due to killing back of the tender sprouts which had started, but soon after the young plants appeared above the surface no difference could be detected in the treated and untreated. The crop was harvested October 8 and the potatoes grown from the several kinds of treated seed were then carefully sorted. Any tubers which had one or more scab spots were placed with the scabby crop. The results obtained are as follows:

Yields of smooth and scabby potatoes from seed differently treated.

	Lbs. smooth.	Lbs. scabby.	Total lbs. per plot.	per cent scabby.
Formalin solution:				
Seed scabby,	776	5	781	0.6
" smooth,	820.5	6.5	827	0.8
Formalin gas:				
Seed scabby,	822.5	9.5	832	1.1
" smooth,	834	3.7	837.7	0.4
Sodium benzoate:				
Seed scabby,	849.5	10.6	860.1	1.2
" smooth,	855.5	15	870.5	1.7
Untreated:				
Seed scabby,	792	55.1	847.1	6.5
" smooth,	819	36.7	855.7	4.3

DISCUSSION OF RESULTS.

The trials of the present year confirm what has already been shown on a smaller scale * that exposure to formaldehyde gas is fully as effective a treatment for potato scab as soaking in formalin solution. Moreover this treatment is much more economical in time and labor when large quantities of seed are to be treated. For example the seed for 25 acres of potatoes could be treated in the room described by using only 4 pounds of potassium permanganate and a little over a gallon of formalin with less than 3 days' delay for the entire amount of seed.

* Vt. Sta. Rept. 18, p. 287.

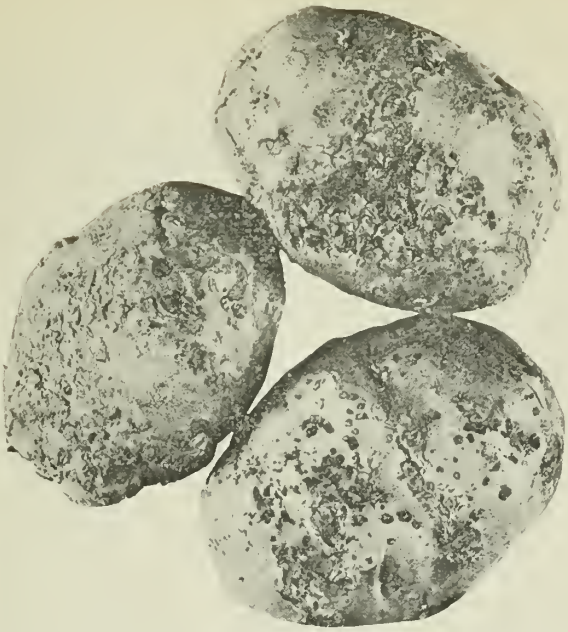


Fig. 46. Samples of "scabby" seed. The tuber at the left shows also sclerotia of Rhizoctonia.

Fig. 47. Samples of "smooth" seed. Note the occasional scab spots.

In commenting upon the fact that none of the treatments entirely eliminated scab from the crop it should be remembered that even the smooth seed had some scab spots, and no treatment has yet been devised which will penetrate the tissues of the potatoes in these spots, kill all the scab germs, and not endanger the germinating qualities of the seed. However, if by treating very scabby seed, the amount of scab in the resulting crop is reduced to 1 per cent or less, it seems reasonable to assume that by using only smooth seed and treating it to kill any germs which may be on the surface the infection of clean ground may be avoided, and probably the danger of increasing the disease on ground already infected will be lessened.

The fact that so little scab developed from the untreated seed detracts somewhat from the value of the results, although a glance at the table shows that in every case the treatment materially reduced the per cent of scab in the resulting crop. However, only 6.5 per cent of scab in a crop from very scabby seed is unusual. For 4 consecutive years the writer found the per cent of scab in a crop from very scabby seed like that in question varied from 19.8 per cent to 63 per cent.* Moreover smooth seed invariably produced less scab than scabby seed and treated seed less than untreated seed. It is of interest in this connection to call attention to the fact already stated that scab in general was very much less prevalent than in the preceding season, although that of 1906 was much the dryer of the two.

It is also of interest to note that sodium benzoate materially reduced the amount of scab in the resulting crop. However, with the present prices quoted for this chemical its use cannot be recommended as a substitute for formalin or corrosive sublimate, the materials commonly used in treating the seed by soaking.

The results from gas disinfection were perfectly satisfactory on the portion of the field where comparatively clean, treated seed was used on clean land. A crop free from scab resulted and it is believed the introduction of scab germs into this soil

* Vt. Sta. Repts. 15, p. 229 (1902); 16, p. 167 (1903); 17, p. 400 (1904); and 18, p. 289 (1905).

was entirely prevented.* On the portion of the field which had been under cultivation for many years, the amount of scab varied in different parts as might be expected. While no attempt was made to secure exact data on that part of the field planted to alfalfa in 1904, there was a marked difference where the fertilizer, lime, and ashes plots were located. Where commercial fetrilizer was used very little scab resulted, somewhat more was observed on the lime plots, while the potato crop was badly scabbed where a heavy dressing of wood ashes were applied when the alfalfa was planted 3 years ago.

WILL FORMALDEHYDE GAS INJURE THE SEED.

In treating a disease like potato scab the following rule must be taken into consideration. "The poison employed must be sufficiently strong or concentrated to kill the parasite, but not sufficiently powerful to injure the host." Five years of experience in treating potatoes with formaldehyde gas generated in various ways indicate that, if properly handled, the gas from 3 pints of 40 per cent formaldehyde may be safely used to the 1000 cubic feet of space. In fact over 3 quarts to the 1000 cubic feet have been used repeatedly without injuring the germinating qualities of the tubers in the least.

However, the experience of one correspondent indicates that the directions for gas disinfection as given in Bulletin No. 141 are deficient in that special attention was not called to the fact that no potatoes should be placed directly over the generator. The action of the potassium permanganate upon a part of the formaldehyde generates considerable heat and makes the liquid boil vigorously. It is this heat which vaporizes the liquid and in a very short time sets free a large per cent of the available gas in the solution. Hence, potatoes directly above the generator are exposed not only to considerable heat but to a gas many times stronger and more active than they would be after the gas became diffused and diluted with the air of the room. The gentleman referred to placed his generator directly underneath and only a few inches below a large slat work bin in

* Mr. Joel Remington of Monticello who treated his seed this season with formaldehyde gas feels sure that by this means he prevented the introduction of scab into his new ground.

which he had placed his potatoes to be treated. As a result, several barrels of tubers were severely injured, the eyes of those nearest the generator being entirely killed.

To test the matter in our own disinfecting chamber a few tubers were placed in a basket and suspended 6 inches above and directly over the generator just before it was charged and were thus exposed during the period of disinfection. All the eyes in these tubers were killed. After a few days the injury was very apparent. The tissues around the eyes were browned and depressed, forming well-marked pits. Cutting into the tubers showed that the injury extended down into the flesh one-fourth of an inch or more. See Figure 49 p. 326.

Samples of tubers exposed during the same period were removed from bins in various parts of the room and taken to the laboratory for examination. None of the eyes were affected and germination was normal.

With the exception of the first 2 or 3 acres planted, the stand on the 20 acres where the seed was treated with gas was exceedingly even and showed very few missing hills. The somewhat uneven stand on the part of the field mentioned was, in the writer's opinion, due to the poorer grade of seed used and to the cold, wet weather which prevailed when the planting was begun, rather than to any effect of seed treatment. The fact that a measured acre of this portion of the field produced a total yield of 168 barrels (462 bushels) indicates that whatever was the cause of the slight uneven germination, the resulting yield was unusually satisfactory on this area. Careful records on acre plots in various parts of the 20-acre field, covering over a third of its area, showed yields varying from 125 to 168 barrels, one other acre in addition to the one already mentioned reaching the latter figure.

ADDITIONAL DIRECTIONS FOR FORMALDEHYDE GAS DISINFECTION.

Recent experience suggests the following modifications and additions to the directions for formaldehyde gas disinfection as given in Bulletin No. 141.

The generator should be placed in an open space in the center of the disinfecting chamber, the bins or crates so arranged that the gas can circulate on all sides of them and

mix with the air of the room. To avoid injury from the strong gas as it is liberated *no potatoes should be placed directly above the generator.*

There is less danger of retarding germination if the disinfection is performed before the sprouts begin to appear.

The gas is more effective if the temperature of the room is 60 degrees to 65 degrees F. at the beginning of the disinfection period than will be the case with a lower temperature.

The gas also appears to be more effective in a moist atmosphere than in a dry one, therefore it is recommended that part of a pailful of boiling water be sprinkled over the floor of the room just before the generator is started. Do not wet the surfaces of the potatoes, for experiments have shown that the gas is more effective on dry potatoes than those which are moistened just before being treated.*

Can Potato Soil be Limed with Safety?

With potato growers clover is usually an important factor in the rotation. Unfortunately clover, like potato scab, thrives best under alkaline soil conditions. To bring about the required alkalinity the practice of liming is resorted to with increasing frequency. The Station has recently secured some remarkably good stands of clover by liming Aroostook potato soils. The question naturally arises, can the amount of lime be so gauged as to produce the required stand of clover and not materially increase the amount of scab when potatoes are again planted on the land? Fortunately one of these trials which was located on the Watson farm at Houlton was made up of a series of alternate acre plots treated with 1000 pounds, 500 pounds and no lime per acre. The lime was applied when stocked with clover in oats in 1905. With a 3-year rotation potatoes would be the crop for 1907, so permission was secured to plow a strip directly across the middle of these plots and at right angles with them. Five long rows of potatoes were planted on this strip. It was intended to use treated seed, but through a misunderstanding on the part of the man in charge of the planting, clean, untreated seed was used instead. The treatment of the

* Vt. Sta. Rpt. 17, p. 401 (1904).

plots with regard to liming was as follows, given in the order that the potato rows intersected the lime plots from north to south: No. 1, 1000 pounds of lime; No. 2, no lime; No. 3, 500 pounds of lime; No. 4, no lime; No. 5, 1000 pounds of lime; No. 6, no lime; No. 7, 500 pounds of lime. At digging time the crop on the rows for about 12 feet either side of a junction of 2 plots was discarded and the per cent of scab in the remaining portion of the rows carefully determined. The results obtained on similar plots were very uniform indeed. The following gives the average per cent of scab on potatoes from each set of plots receiving the different applications of lime:

Treatment,	1000 lbs. lime.	500 lbs. lime.	No lime.
Per cent of scab on potato crop,	49	27	11

DISCUSSION OF RESULTS.

It would seem from this experiment that the application of 1000 pounds of lime per acre is likely to lead to a dangerous increase in scab unless a longer period than 3 years is allowed before potatoes are again used in the rotation, for there was more than 4 times as much scab on these plots as on those which received no lime. Five hundred pounds of lime per acre increased the amount of scab nearly 3 fold. The only conclusion that can be drawn from this single experiment is that sufficient lime to produce marked increase in the clover and grass yields is likely to also produce a marked increase in scab on potatoes used in a 3-year rotation on infected soil. However, it is possible that the amount of scab might be largely decreased by the following procedure: First, the use of clean, treated seed. Second, the season before the potato crop is to be planted the clover crop could be cut early in July. The second crop of clover would be allowed to grow well into September and then plowed under before being killed with frost. This would not only supply considerable fertilizing material for the following potato crop but the production of more or less acid resulting from the decay of the relatively large quantity of organic matter would tend to neutralize the lime and make conditions less favorable to scab.

Internal Brown Spot of the Tuber.

A peculiar spotting of the interior of potato tubers has been observed for some time by Mr. Charles Fish of Brunswick. Samples were sent to the Station and examination showed that the appearance of the diseased potatoes agreed in every respect with the published description of the "internal brown spot" which is quite common in some parts of Europe. So far as the writer can learn the occurrence of the disease in America has been recorded in the publications of but 2 of the Stations.* In Scotland and England this disease is more commonly known as "sprain."

The surface of the tuber looks perfectly healthy and normal. On cutting open the affected ones the flesh is found to be dotted with rusty-brown spots as is illustrated in Fig. 48, which represents a series of consecutive slices through the same tuber. These spots vary in size from minute dots to one-eighth of an inch or even one-fourth of an inch in diameter. The diseased areas are of various shapes but more often approach the spherical in general outline. The affected portions are not confined to any particular portion of the tuber, and where they are few enough to be isolated from one another the spots are entirely imbedded in what appeared to be healthy tissue.

A larger supply of the affected tubers was secured to determine whether or not the disease was of parasitic origin. Careful examination with the microscope failed to show the presence of either fungi or bacteria. Neither could any such organisms be isolated from the spots—the diseased areas appeared to be sterile when cut out with a flamed knife and transferred with proper precautions to tubes or plates of nutrient media.

The variety examined was Burpee's Extra Early, grown on rather dry, sandy loam. A special brand of commercial fertilizer for potatoes was used but no stable dressing was applied. Mr. Fish states that he finds considerable difference in the resistance of various varieties to this disease. Green Mountain is not very susceptible, while Early Prolific was badly affected one season. The amount of spotting present varies also with the season.

---

* Minn. Exp. Sta. Bul. 39, pp. 212-213 (1894); Bul. 45, p. 310 (1895). N. Y. (Geneva) Bul. 101, pp. 78-83 (1896).

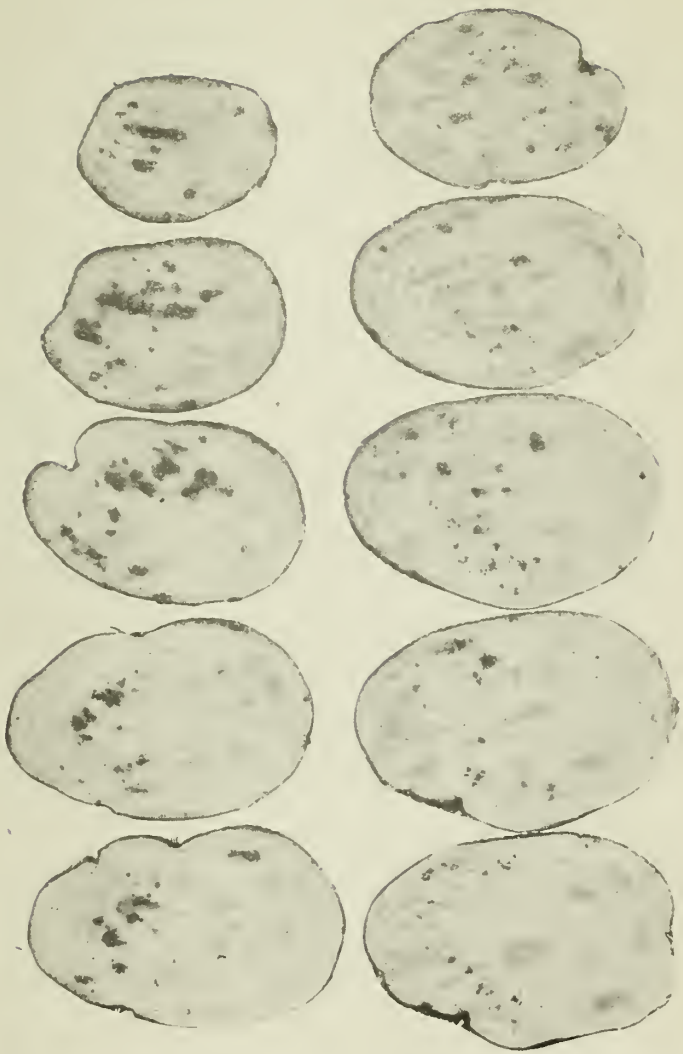


Fig. 48. Internal Brown Spot showing a series of slices through the same tuber.

Dr. Jones,* who has made a careful study of this disease as it occurs in Europe, makes the following statement with regard to the causes and treatment:

"It is not propagated in seed or soil and is non-parasitic. It is considered to be the direct result of malnutrition associated with unfavorable soil conditions, resulting either from too dry conditions or from the lack of potash and lime. It is frequent in light, dry soils, during dry seasons, and is never seen on heavy, strong, moist soils. The remedy, in the judgment of the specialists cited, lies wholly in attention to cultural conditions and the choice of varieties.

"Some varieties are more liable than others to internal brown spot and should not be used on soil that favors the disease; e. g. Mr. Scarlett stated that the British Queen variety is especially predisposed to 'sprain.' The primary remedy, however, lies in the selection and treatment of the soil—i. e., avoiding dry soil—and in so cultivating as to conserve moisture, while using lime and potash liberally."

From our present knowledge it would seem then that this is not a disease to be feared on soils which are particularly adapted to potato culture and that there is no danger of its spreading like a parasitic disease. It is, therefore, one of the so-called physiological diseases and due to purely local soil conditions. There is some lack of balance in the nutrition of the plant when grown on certain soils which is indicated by the spotting of the tubers. What this is and how to remedy the condition we do not know except as indicated above.

At our request Mr. Fish planted some of the diseased tubers last spring. Writing on October 29 he states that the plants from these tubers grew as vigorously as any others in the field and produced a good crop of sound potatoes. No brown spots could be found in any of them.

Surface Spotting of Tubers by *Phytophthora infestans*.

In the early spring of 1907 several growers and shippers called the writer's attention to what they felt sure to be a new potato disease, characterized by a spotting of the surface or

* Jones, L. R., Bureau of Plant Industry, Bul. 87, p. 13 (1905).

skin of the tuber. It was seen only on the Irish Cobbler variety and was wholly confined to the early dug portion of the crop.

The spots, which were black, varied from the size of a small pea to one-half an inch or more in diameter, and showed up in marked contrast to the clean, white surface of the potato. Little or no shrinking of the tissues below the blackened area was apparent. On cutting into a spot it was seen to extend only through the skin and practically none down into the tissues below. The appearance as a whole suggested the late blight fungus, *Phytophthora infestans,* (also the cause of the common dry rot), as a possible explanation of the cause. However, it differed from the appearance of the ordinary dry rot enough so that none of the shippers would agree that it was the same thing. Furthermore, a careful search late in the preceding August over some of the fields on which affected potatoes were grown failed to produce a single characteristic specimen of late blight on the foliage. Samples of the diseased tubers were taken to the laboratory and placed in a moist chamber. Before doing so, the whole tubers were carefully washed and dried, and then cut across through one or more diseased areas, using a flamed knife. After 2 or 3 days the cut pieces were examined and in every case the characteristic spore clusters of *Phytophthora infestans* could be found along the cut margin of the diseased areas. No other fungus was found associated with the spotting.

The potatoes on which the spotting occurred were dug early in September. The tubers were not mature and were easily skinned and bruised by the digger and in handling. Without doubt the fungus was at that time present on the leaves in a very slight degree. The spores falling on the bruised tubers germinated, but on account of adverse temperature and moisture conditions the mycelium passed at once into a resting state, instead of penetrating farther into the tissues and producing the usual characteristic dry rot of the tuber.

Potatoes showing these spots as well as those showing the ordinary dry rot should be rejected for seed. The use of unsound tubers for seed is one of the sources, and possibly the only source from which late blight is conveyed to the foliage of the growing crop.

Black Leg of Potatoes.

Late in July the Station Entomologist noticed that many of the potato stems on one field at Sherman were blackened and decayed at the base. Examination of the specimens which she collected showed that they were affected with what is known in England as "black leg." This is a disease, or more likely in the present case, one of a class of similar potato stem diseases which has begun to attract considerable attention in America within the past few years. It has not been previously reported from Maine, and so far as the writer can learn was first credited to New England by Jones in 1906.* It is interesting to note that he makes the following statement with regard to the seed used on the field where the outbreak occurred: "The field was planted with Green Mountain potatoes, the seed being from Houlton, Maine."

The field in Sherman where the diseased stems were first found was visited with Miss Patch on July 30. This was on rather low land which had recently been cleared, having never been under cultivation before. The field where the seed was grown was some miles away and planted to another crop, therefore no attempt was made to discover if the disease occurred on the original field. However, as will be seen later, there is some reason to think that the disease is carried with the seed. Affected plants were scattered all over the field, but probably less than one per cent of them were involved. When the field was examined, and in fact the same is true of all the fields seen later, the disease had apparently passed its greatest period of activity and was now on the decline. Affected plants could usually be detected some distance away. Their leaves were, as a rule, of a lighter green or yellowish color, especially in the later stages of the disease. The diseased plants were almost invariably more compact than the healthy ones, due to the upward trend of the lateral branches and petioles. The leaves also tend to curve upward, the younger ones folded upward along the midrib. Occasionally small green tubers could be found on diseased plants growing in the axils of the leaves above ground. Careful observation showed that any one of

* Jones, L. R., Vt. Sta. Rept. 19, p. 257 (1906).

these external symptoms mentioned might result from any other cause which injured the stem near or just below the surface of the ground and thus interfered with the free transference of nutrient substances.

Examination of the diseased plants showed that in every instance the stem was more or less blackened or browned usually at or just below the surface of the soil and downward. At Sherman, however, a few specimens showed the blackening following up the main stalk and branches for several inches. Frequently the diseased portions of the stem were very soft, resembling the decay caused by soft rot bacteria, while other cases, possibly in the later stages, showed more of a dry rot. In every case where the seed tuber could be found it was soft and mushy as though attacked by a soft rot. The seed tubers of healthy potatoes were, as a rule, sound and remarkably well preserved.

Another field at Sherman, about a mile from the first, contained from 5 per cent to 15 per cent diseased plants, the higher percentage being on the more poorly drained portions of the field. A few fields were found at Houlton where diseased plants were quite frequent, but here as in some other places a careful search over any large field would occasionally produce isolated plants which were affected. Late in the season outbreaks were discovered at Dover and at Orono. At the former place was secured the only evidence of possible spreading of the disease in the field. Here the portion involved was situated in a somewhat depressed area in an otherwise well-drained field. The owner, a professional man, had had the matter under observation for some days before the field was seen by the writer. He was well satisfied that the diseased area was gradually enlarging. In fact when the field was visited the plants on the margin of the somewhat circular, diseased area showed earlier stages of the disease than those in the center. In all other cases examined there did not appear to be any evidence of spreading from plant to plant or from hill to hill. If 2 diseased stalks were close together it was invariably found that they arose from the same seed piece.

The case at Orono would indicate that the disease is transmitted with the seed. Here all the seed on a 4-acre field was obtained from away, and from 3 or 4 different sources. Two

of these lots of seed, consisting of a single barrel each, were planted on one side of the field under exactly the same conditions. The plants from one of these barrels of seed were found to be quite generally attacked by "black leg" late in August, while not a single diseased stem could be found on the remainder of the field. A barrel of seed from this portion of the field was saved for future planting.

For a similar diseased condition Selby * has given the name "potato rosette," while Rolfs has used the terms "little potato disease," "collar-rot," etc.† Jones apparently prefers the name "black leg" which is commonly used in England. The evidence seems to be pretty conclusive that the disease as it occurred in Ohio and Colorado is due to the fungus *Corticium vagum var. Solani,* Burt., or as it is more commonly known, the potato *Rhizoctonia,* while the similar trouble known as *Schwarzbeinigkeit* in Germany has been ascribed to certain bacteria. Harrison has more recently described a new bacterial rot of the stem and tuber due to *Bacillus solanisaprus.* This organism was most carefully studied by him and its ability to produce the disease fully demonstrated.‡ The article in question was not available to the writer till after the observations herein recorded were made, but the evidence strongly suggests that the Maine potato stem trouble is identical with Harrison's bacterial disease which he states is widely distributed over various Canadian Provinces.

Microscopic examination of a large number of diseased stems both before and after being placed in a moist chamber almost invariably failed to show *Rhizoctonia* hyphæ. One case was noted where spores resembling those of the *Corticium* stage were observed, although they were somewhat larger than those described by Rolfs. Very frequently indeed spores were found which in shape and size agreed perfectly with the description of macroconidia of *Fusarium oxysporium,* as published by Smith and Swingle.§ Preparations from stem where the diseased

---

* Selby, A. D., Ohio Exp. Sta. Bulletins No. 139 and 145 (1903).

† Rolfs, F. M., Colo. Exp. Sta. Buls. 70 (1902); 91 (1904).

‡ Harrison, F. C., A Bacterial Rot of the Potato, caused by *Bacillus solanisaprus.* Centralblatt f. Bakt. u. Parasitenkunde, Bd. XVII, II Abt. 1906.

§ Smith, Erwin, F. and Swingle, Deane B., Bureau of Plant Industry, Bulletin 55, p. 30 (1904).

portions had not become dry invariably showed myriads of motile bacteria. As farther evidence that *Rhizoctonia* is probably not primarily the cause of the disease as it occurs in Maine it should be noted that the occurrence and distribution of the fungus is far out of proportion to the amount of "black-leg." *Rhizoctonia* sclerotia are of almost universal occurrence on the tubers everywhere in the State. Examination of the old potato tops which had lain out all winter, in widely separated localities, showed that the old, dried stems were invariably studded with these same black sclerotia. Figure 50 is a fair representation of the appearance of these stems from one field. However, repeated searching during the summer over an 8-acre field planted with seed from the same source failed to reveal but one stem affected with "black-leg."

Attempts to produce the disease in the field by inoculation with pieces of diseased tissues and from cultures were without success and greenhouse facilities with which to follow up the matter with younger plants with control conditions were not available. Therefore, little was accomplished other than described above in determining the cause of the disease as it occurs in Maine.

The writer is fully aware that the foregoing adds little to what is already known with regard to this class of potato stem diseases, other than enlarging the range of distribution. However, this somewhat extended account is given with the hope it will cause Maine growers to be on the lookout for potato stem diseases and to report them at once to the Station with samples for examination. In this way they will materially assist in the studies which are now planned for the coming season.

In conclusion it should be stated that so far as the present knowledge of the disease as it occurs in this State goes there need be no cause for serious alarm. The severe outbreaks observed were largely on low, poorly drained soil, not well adapted to potato culture. It is not believed that "black leg" will ever become in Maine so serious a pest to handle as scab. There is considerable reason to believe that it may be transferred from one field to another with the seed, therefore seed from infected fields should not be used. The suggestions with reference to the use of clean, smooth seed, disinfected with formalin or formaldehyde, apply equally well here as in the case of scab.

Fig. 49. Tuber injured by improper use of formaldehyde gas. See p.

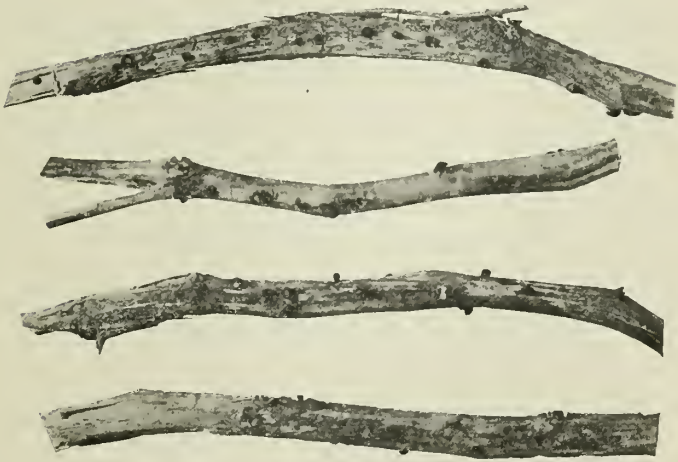


Fig. 50. Dry potato stems studded with Rhizoctonia sclerotia. Collected in May.

As a general precautionary measure against all potato diseases the collection and burning of all weeds, litter and tops as soon as the crop is harvested cannot be too strongly recommended.

Red Lead as an Insecticide.

Last spring a correspondent at Gray wrote the Station that Mr. J. E. Leighton of that place was successfully using red lead as a substitute for Paris green to destroy the larvæ of Colorado beetles on potatoes. Investigation showed that Mr. Leighton had been using this material for 3 years, applying dry about 10 pounds per acre, diluted with wood ashes. He stated that the red lead was very adhesive and remained on during the entire season. That, whereas he was obliged to go over his field repeatedly with Paris green, it was unnecessary where red lead was used, except to protect new growth. Mr. Leighton stated that in his experience, not only did the red lead keep the foliage clean from the Colorado beetles but the leaves on the plants where it was used remained green for 2 or 3 weeks longer than was the case where Paris green alone was used.

To test the matter one-half of a small field of potatoes was sprayed on July 9 and again on July 20 with bordeaux mixture containing 10 pounds of red lead to 50 gallons of mixture. The other half was sprayed with bordeaux mixture containing 1 pound of Paris green to 50 gallons. The spraying was quite thoroughly done so about 75 or 80 gallons of mixture per acre was applied, thus using about 15 pounds of red lead and 1½ pounds of Paris green per acre. The red lead proved to be very hard to use with bordeaux mixture. On account of its relatively high specific gravity it all settled to the bottom of the spray tank, forming a thick, pasty mass by the time the field was reached. In order to spray it on at all it was necessary to remove the hose from the nozzles and pump the mixture back through the hose into the tank for several minutes, till it became thoroughly mixed. Then the mixture had to be kept constantly agitated and applied at once.

Both the Paris green and the red lead cleared the foliage of insects, but while the former killed them, as was evidenced by the dead on the ground, the latter simply acted as a repellent. No dead insects could be found under the plants sprayed with

red lead, but the largely increased numbers on nearby, unsprayed plants showed that they had migrated to these. The length of time that a spraying with red lead would protect the foliage did not appear to exceed that of Paris green. The only conclusion that could be drawn from the field trials was that while red lead used in sufficient quantities will keep the larvæ away from potato foliage there is nothing to recommend it as a substitute for Paris green as an insecticide.

In order to determine just what the action of red lead is upon the young larvæ the Station Entomologist tested the matter in the insect house. The results of her experiments and her conclusions are as follows:

"Twelve insectary tests were made to determine the value of dry red lead as an insecticide, about 50 potato beetle larvæ being involved in each test. It was found that leaves heavily coated with red lead were to a very considerable extent avoided by even the large larvæ and this substance has some value as a repellent. Some of the very young larvæ that trailed through the red lead which adhered to them died, and this powder served to a slight degree, therefore, as a contact insecticide. Without going into the details of any of the tests it is perhaps sufficient to state that of the 2 lots of larvæ caged July 27 at 4 P. M. upon potato plants, one of which was treated with red lead and one with Paris green in exactly similar ways, an examination July 28 at 9 A. M. showed 50 live and apparently healthy larvæ in the red lead cage and 43 dead and 7 alive (part of which subsequently died) in the Paris green cage."